THE

Malayan Agricultural Journal.

Vol. XIII.] APRIL, 1925. [No. 4.

SOME OBSERVATIONS ON THE MALAYSIAN COCONUT ZYGAENID (*ARTONA CATOXANTHA* HAMPS)*

By B. A. R. Gater.

INTRODUCTION.

NOTE.

1. Owing to delay in reproduction the plate to accompany this paper will be issued in a subsequent number.

2. Page 97 lines 17 and 18 should read :—" .... between 2 p. m. and 6.30 p. m. and again between 6.30 a.m. and 9 a.m."

rarely has the pest affected European-controlled estates. The fact that the pest is notifiable under the Agricultural Pests Enactment assists in its presence being reported early, but the apparent inability of the cultivator to see the caterpillars until the leaves are swarming with them delays the information until too late for the investigation of the earlier stages. The result of this is that the causes of outbreaks are unknown, and shortage of personnel has prevented a member of the staff being stationed in a possible locality to watch for the beginning of an attack.

Happily the attacks are always eventually controlled by natural enemies. As it is, the damage done is considerable, and were the insect to be imported into a country without its natural enemies the danger would be of the gravest character.

Not only is the biology of this insect of great importance to the coconut industry in Malaysia, but it is also of importance in that

*It is intended to follow up this preliminary account with more extensive studies of the various phases of the *catoxantha* problem.

efforts are being made to use its parasites to control a nearly related Zygaenid which is destroying the coconuts on one island after another in Fiji.

Acknowledgement is due to those gentlemen who have materially assisted the production of these notes by the loan of records and in many other ways, particularly F. W. South (Chief Field Officer), C. T. Darwent (Medical Officer, Batu Gajah), and T. C. A. Cleverton (Medical Officer, Labuan); and Dr. Guy A. K. Marshall (Director, Imperial Bureau of Entomology) for the identification of species. Mention must also be made of the valuable assitance received from Mohammed Yusope, Junior Agricultural Assistant in the Entomological Laboratory.

HISTORY.

The moth was first described as *Brachartona catoxantha* by Hampson (1) in 1892 from specimens taken in the Tenasserim Valley. Dr. K. Jordan (4) however, includes *Brachartona*, Hamps. in *Artona*, Walk. The first mention of a food plant in literature appears to be by Ridley (2) in Malacca, but Pratt (3) writing of an attack at Batu Gajah in 1907 mentions that it was said to have been known there seven years before, about 1900. In 1908 Königsberger (5) described some of the stages, but failed to find the eggs. Since 1909, when Pratt (6) published an account of its life history and suggested control measures, the number of reported cases appears to have increased. Whether this is due to an actual increase and spread or to more frequent and accurate diagnosis it is difficult to say, but on the whole it would not seem unreasonable to assume that attacks are more prevalent now than in the past.

As far as is shown by the available records for Malaysia, *catoxantha* is the only Zygaenid of any economic importance. According to Jordan (4) *Artona lucasseni*, Snell. feeds on *Bambusa* while *A. quadrisignata*, Snell. and *A. trisignata*, Snell. feed on an unidentified plant known as "Dawon Houndjek," in Java. *Levuana iridescens*, Baker, is a serious pest of coconuts, as well as feeding on other palms and banana, in Fiji. The life history and habits of the latter insect are similar to *A. catoxantha*, and the co-operation of this Department was sought by the Fijian Government in order to control it by the introduction of parasites from Malaya.

DISTRIBUTION.

Jordan (4) gives the distribution of the genus *Artona* as Indo-Malayan extending northwards to North-East Thibet and eastwards to the Celebes. *Artona catoxantha* has been recorded from Java, Sumatra, Labuan, Sandakan and Malaya. Within the Malay Peninsula it has been recorded at Batu Gajah; several districts in Province Wellesley, Perak and Selangor; at Johore Bahru, Malacca and Singapore. The presence of the feeding marks made on the pinnae by the caterpillars has been noted on nearly every coconut estate visited in Malaya. The feeding marks are so typical, and differ so markedly from those made by any other known coconut insect, that it should

be safe to assume that the distribution in the Malay Peninsula is general. Outbreaks tend to recur in certain localities, notably at Batu Gajah. Little evidence is forthcoming as to whether this is an introduced or indigenous insect, except the number of parasites affecting it, from the extent of which it may be assumed that it is indigenous. Recently, however, an attack occurred at Pulo Kuraman, an island near Labuan. From there the pest spread to other small islands in the vicinity and to the nearest point on the island of Labuan, where it almost immediately died out. None of the typical feeding marks could be found on the coconuts in Labuan, and since the coconuts at Pulo Kuraman were planted on newly felled land where none existed before, it did not appear that the insect had originated either in Pulo Kuraman or Labuan. The absence of parasites, and the total absence of the Tachinid so common elsewhere, forces the conclusion that the pest was imported. There are many ways in which this could be done, and evidence from the Labuan area points to a definite danger of spreading this insect by the unrestricted importation of coconut material.

LIFE HISTORY.

Unfortunately the moths have so far refused to copulate in captivity and great difficulties have been encountered in rearing the young caterpillars under laboratory conditions. The life-history has thus been worked out only in piecemeal form, probably with not very accurate results. The time taken by the various instars to develop has, however, been found to be sufficiently accurate for calculations in the field. Outbreaks of this insect have rarely occurred on young easily accessible palms, the older palms usually being affected. It is intended to study the life-history further by mass methods on small growing palms.

Copulation appears to take place on the same day as emergence, the male dying one or two days after. Eggs are laid from two to three days after copulation, the female dying the day after oviposition. In the field however, the length of the adult life is probably much longer than is indicated by these figures, and may last as long as two weeks. Eggs are laid singly on the under surface of the pinnae, generally towards the tip, the older rather than the younger leaves seeming to be preferred for oviposition. The average number of eggs laid appears to be 40, but instances have been observed in which as many as 57 have been deposited by a single female.

The Egg.

The egg is slightly oval in shape, smooth, slightly flattened and of a translucent pale yellow colour. Average size 0·5 x 0·25 m/m.

The incubation period is three to five days (observed range) the mean period being four and a half.

The Larva.

The first instar is only a millimetre in length and pale greenish-yellow in colour. The thorax is broader than the abdomen, which

tapers towards the anal claspers. Duration four to five days. The second instar is about 2 m/m in length and is more visibly hairy. After an interval of 4 to 5 days the second moult takes place, the third instar being similar to the second except in size, which is now 3—4 m/m. The duration of the third instar is about 4 days. The fourth instar is 4—6 m/m in length, the coloured dorsal markings of the full grown larva being apparent. Duration four days. The fifth instar is 6—8 m/m long, with ten abdominal segments. The greatest breadth is now at the first abdominal segment, which is very little broader than the rest of the body. The head is invaginated into the first thoracic segment. Mandibles dark brown with sharp untoothed edges. Prothorax and metathorax yellow, the prothorax being larger than the other thoracic segments and shaped like a cowl. Abdomen pale yellow, frequently with a green tinge, legs on thoracic segments small, prolegs on abdominal segments 3 to 6, anal claspers on the 10th. On the mid-dorsal surface of the abdomen there is a longitudinal blue or purple fascia, extending from the third thoracic to the ninth abdominal segment. Small areas similarly coloured may be seen on the sides of the 3rd thoracic and on the 1st and 8th abdominal segments, while a larger area is present on the mid-dorsum of the 9th abdominal. Glandular hairs are present in groups situated in longitudinal lines along the body, one group to each segment. There are two subdorsal rows of these groups of hairs and a lateral row extending from the 3rd thoracic to the 8th abdominal segment. On thoracic segments 2 and 3 there are five groups on each side, and on abdominal segments 3 to 6 there are 4 rows, the extra groups being sub-lateral in each case. The first thoracic and tenth abdominal segments bear no groups of hairs but are fringed on their distal portions. The ninth abdominal has two groups on each side placed sub-dorsally and close together. The hairs of the first or upper subdorsal row of groups are of medium length. The hairs of the second or lower subdorsal row are of the same length but with one long hair arising from each group, whereas in the lateral row there are several longer hairs arising from each group.

The Cocoon and Pupa.

The full grown larva spins a tough papery cocoon which is dirty white to fawn in colour. It is elliptical in shape, 11—12 m/m long, 5—6 m/m broad and flattened on to the leaf.

The pupa is 7—8 m/m long and immediately after its formation is of a light translucent yellow colour. The ten abdominal segments are still visible and a row of short spines is present on the anterior dorsal portion of segments 3 to 7 in the female and 3 to 8 in the male. It is by means of these spines that the pupa is enabled to make its way out of the cocoon just before the moth emerges. At the apex of the tenth segment there is a small group of short blunt spines. The colour gradually becomes darker, and just before emergence the colours of the adult can be clearly seen.

The Imago.

The following description is modified from Pratt (6) and is fuller than that given by Hampson (1):—

Length 7—8 m/m., wing expanse 13—16 m/m. Upperside uniform chocolate brown. Scales on anterior portion of prothorax and posterior portion of head yellow, showing as a collar. Frons yellow with a median brown stripe. Palpi yellow. Costa of forewings yellow; scales fringing both wings lighter brown to yellow; costal margin of hind wing dirty white to yellow. Underside of forewings lighter brown with costa yellow, the yellow terminating broadly near the tip. A broad yellow band along the costal margin of hind-wing, divided by a radial brown stripe; posterior portion of hindwing uniform with forewing. Underside of body and legs, yellow; antennae chocolate brown, often showing a bronze tint, especially in males, and slightly yellow towards the tip in some females. Genital aperture fringed with long yellow scales. Female slightly larger, antennae filiform Male with pectinate antennae.

The following is a summary of the life history :—

LIFE HISTORY OF *ARTONA CATOXANTHA*

Period.	Range :— Days.	Mean :— Days.
Copulation to oviposition -	2 — 3	2·0
Incubation of egg -	3 — 5	4·3
Instar I. -	4 — 5	4·6
Instar II. -	4 — 5	4·8
Instar III. -	3 — 5	3·6
Instar IV. -	3 — 4	3·9
Instar V. -	6 — 7	6·7
Pupa -	8 — 10	9·0
	Total	38·9 days.

HABITS.

As soon as the young caterpillars hatch they begin feeding on the epidermis of the underside of the pinnae in straight lines. The feeding marks are typical and have the appearance of ladders. At the beginning of an outbreak the caterpillars are confined to the lower leaves of the palm, but as they increase in numbers during successive broods they swarm over every portion of the plant, even to the spathe and nuts. Königsberger (5) states that feeding takes place on the upper surface of the leaf, but this cannot be said to be the habit in Malaya. A few caterpillars may occassionally be seen on the upper surface, but practically the whole of the feeding is confined to the lower surface. During the last instar feeding may also take place by the ordinary method among caterpillars, namely by eating the edges of the pinnae.

Cocoons are spun on the underside of the leaves at first, and, in the later broods, on any portion of the palm including the stem.

Such quantities of caterpillars are present in bad outbreaks that every available space is occupied by the feeding caterpillars and old cocoons, and cocoons may often be found on the ground and on low-growing plants in the vicinity. During the larval stage hundreds of caterpillars can be made to drop down by shaking a leaf, and they remain suspended by thin silken threads. It is these caterpillars which eventually spin their cocoons on the ground and surrounding plants, since they are not always able to reascend the palm when once they have dropped. The larval hairs are poisonous to a certain extent, sufficient to deter coolies from ascending a palm infested with caterpillars.

The moth has not been observed feeding, and Corbett and South (12) state that there are strong indications that feeding does not take place. The haustellum is, however, well developed, and it is probable that the moths feed in some way not yet determined. According to the same observers the moths are not attracted by light or sugar mixtures, fly actively between 9 p.m. and 6.30 p.m. and again between 6.30 a.m. and 2 a.m. Resting periods occur during the remainder of the day, during which they may be seen clustered on the pinnae, especially of the upper leaves, in a semi-erect attitude. The moths do not appear to be strong flyers, most of the flying being probably done by the males. They spread from tree to tree slowly, the line of spread being generally along the edges of open spaces such as roads. The length of the flight can, however, be aided to a great extent by wind. In Labuan (15) flights up to two miles have been observed when aided by a strong wind, but on arrival the moths died and no eggs were laid.

FOOD PLANTS.

The principal food plant is the coconut palm. Other palms are attacked but only, so far as has been seen, when they are in the vicinity of coconuts during an outbreak. Feeding marks have never been observed on any other palm than coconut, but in one instance a dead caterpillar which appeared to be *Artona* was found on a nipah palm, and it had been parasitised by a Chalcidoid similar to one observed in Batu Gajah. During the periods when there is no outbreak repeated search of the area has never revealed a single living caterpillar or cocoon, although feeding marks can be seen. There is therefor every possibility of a wild food plant existing, and the feeding marks on coconuts may be those of another Zygaenid which is as yet unrecorded on palms. The following palms other than coconut have been observed to be attacked :—

(1) Nipah (*Nipah fruticans*, Thunb.)

(2) Areca (*Areca catechu, L.*)

(3) Nibong (*Oncosperma tigillaria*, Hort.)

(4) Sago (*Metroxylon sagu*, Rottb.)

(5) *Calamus* sp.

In Labuan, where areca and sago palms were present in the area attacked, the latter were damaged while the former remained free. Searching other plants in the vicinity of outbreaks for the stages of this insect has invariably yielded negative results except in the case of cocoons which, as mentioned above, will be made anywhere where the full grown caterpillars happen to be.

ECONOMIC STATUS.

Damage to the coconut palm consists of stripping the plant of practically the whole of its foliage. The actual amount of leaf eaten depends on the severity of the attack, and varies from the destruction of the lower leaves only, to almost total defoliation extending to the younger leaves. In general, however, the youngest leaves are not damaged to any appreciable extent, thus enabling the palm to recover from the attack. Leaves which have been partially eaten turn brown and wither, the result being almost the same as if they had been completely eaten. The feeding marks also expose the palm to fungi or other disease agents, which are enabled to penetrate the epidermis. No records are to hand of palms having been killed by *catoxantha*, but the set-back received is very serious, especially in cases where nothing but the mid-ribs of the pinnae are left, when the palm has to wait until it can produce new leaves.

As a result of the serious set-back received there is a considerable loss of crop, both through the young nuts failing to develop and owing to the more mature nuts falling off. The loss of crop has been variously estimated, but owing to differences in the severity of attacks it is difficult to estimate the loss due to what might be called an average outbreak. The loss of a year's crop owing to an attack of average severity is, however, generally considered to be a reasonable estimate. If the number of nuts per acre per annum be taken as 2,500 the loss is equivalent to half a ton of copra per acre. Thus although the palms are not killed, an outbreak on an estate is accompanied by very considerable monetary loss. A number of outbreaks at short intervals of time would mean little less than disaster to a large coconut estate.

PERIODICITY.

Outbreaks do not, fortunately, recur at regular intervals of short duration. Although there are recurrent outbreaks in certain areas they do not, as far as available records show, appear to have any definite periodicity.

Outbreaks have been stated to occur every two, three, four and up to seven years, but no evidence in support of these statements can be found. The actual duration of an outbreak is, however, much more definite, few cases being recorded where more than six broods occurred before the attack was ended. In some instances the attack is of very short duration. On one estate which was visited by the writer in April 1924 a thin infestation was present which was estimated to have started in February. At the time of the visit the caterpillars were heavily parasitised and no further trouble was

experienced. On the other hand some attacks last longer than the sixth brood, and judging from reports from Java some attacks there continue for well over a year.

CHECKS.

In view of the fact that in 'normal' times *Artona catoxantha* is not a pest and that the number of known enemies which help to keep it in check is considerable, the parasites and other factors inimical to its rapid development form the most important aspect of the problem.

As already stated the conditions bringing about an outbreak are at present unknown, but one or two indications suggest that general external conditions play an important part. It is unknown if one or more parasites normally keep *catoxantha* in check, or whether of the large number found during an outbreak, especially in the later stages, many are incidental and not confined to one host in nature. As far as external conditions have been observed, a curious relation appears to exist between the practice of burning fires under the coconut trees and outbreaks. The latter have generally occurred on native small-holdings, and it is a custom among Malays to burn fires at the base of the palm in order to stimulate the production of nuts, a practice which is of very doubtful benefit to the palms and which is not permitted on European-managed estates On those occasions on which outbreaks have occurred on European estates there has always been a previous history of burning under the trees within a comparatively short time. On many coconut estates the dead leaves, husks and other rubbish are spread out and allowed to rot on the ground in order to provide humus. On one estate where this practice is carried out the apparent feeding marks of the caterpillars can always be seen, but there has never been an outbreak. In four cases, however, where rubbish had accumulated to a large extent, it was burnt under the trees, and an outbreak of the pest followed. In one case a curious instance of this relation between outbreaks and burning was observed. An estate had an outbreak in progress which was gradually spreading along a road to another estate a few miles away. On examination a few palms were found to be affected on the latter along the edges of the road, and no signs of the pest could be seen in the adjacent areas on this estate. It was somewhat surprising, therefore, to find five palms infected in the centre of the estate about a mile in a direct line from the nearest point along the road, and to learn that it was at this spot that the garden coolie had burnt a quantity of rubbish. In another instance *catoxantha* appeared on an estate which had become very overgrown with weeds and which was being cleared by areas, the rubbish being burnt under the palms. Burning in this instance was stopped at once and the insect did not appear on any other portion of the estate.

These instances are no proof of the action of heat or smoke on the insects, but are curiously repeated in various outbreaks. The phenomenon would appear to point to one or more of the parasites being particularly susceptible to changed conditions and dying off under the influence of smoke, heat or fumes. That slightly changed

conditions do affect parasites, thus allowing the pest to increase rapidly, is well known, and there are at least some grounds for suggesting that an influence of the above nature is a contributory factor in bringing about outbreaks. It is also possible that some stage in the life-history of one or more of the parasites is spent in the rubbish, where they would be killed by burning. It can be confirmed or refuted only by the quantitative study of the actual insects and by an attempt at the experimental production of an outbreak.

Food appears to have no influence on the activities of *catoxantha*, since there is abundant coconut leaf available throughout the year, nor does there seem to be any indication of periodicity in its life history. The factor which influences it must therefore be something in the nature of the fires acting on parasites, or it must be the interrelation of the parasites and the hyperparasites, or meteorological conditions.

Natural Enemies.

The natural enemies of the insect attracted attention when it was first noticed. Thus Pratt (6) mentions that 20% of the larvae were parasitised at one place. Richards (11) reports the presence of a Phorid as a parasite, which has, however, not been observed since, and van Heurn (13) says that four species of *Mesostenus* attack the larvae. Roepke (8) noted that one species (afterwards identified as *Mesostenus*, see van Heurn), which he named Parasite "C," also attacked the Tineid, *Acrocercops cramerella*, Sn. Up to the present no parasites have been observed on the eggs, but in the Federated Malay States the writer has taken eight Hymenoptera parasitic on the larvae, while two others, which were single specimens and have been sent away for identification may be the same or different to these. The empty pupal cases of an Hymenopterous ectoparasite have been observed, but the adults have not been taken. This parasite apparently attacks the caterpillar in considerable numbers, twenty to thirty pupae, placed close together on the shrunken larval skin, having been seen on several occasions. In addition to these, three Tachinids have been found, making a total of twelve separate parasites, possibly fourteen. There is also an insect predaceous on the larvae and pupae. One of the Tachinids, the common one which has been investigated, has yielded a total of seven hyperparasites. Only a very small proportion of these insects has been identified, and little is known about them with the exception of the Tachinid ; moreover, in the present state of our knowledge all of them cannot be set down definitely as primary parasites. A rough description of the insects is given below which is sufficient to separate them one from the other for purposes of record.

Goryphus maculipennis, Cam. This is the largest Ichneumonid parasite, being 7 m/m long. The general colour is black, part of the mesothorax and the whole of the metathorax and the petiole of the abdomen being orange yellow. A yellow transverse band on the abdomen. Wings dark coloured in the centre.

Goryphus maculiceps, Cam. Similar to *maculipennis* but smaller, being 5 m/m in length. Wings more shaded. Two yellow transverse bands on the abdomen.

Microgaster sp., No. 576. This Braconid is not common, and the specimens are at present at the British Museum.

Tetrastichus sp., No. 575. Another uncommon parasite, and specimens are at the British Museum. (Chalcididae).

Callimerus sp., No. 1475. This Clerid beetle and its larvae are usually found in small numbers feeding on the pupating larvae and pupae of the moth. Pupal period 10—12 days.

Braconid No. 1085. This is perhaps the commonest Hymenopterous parasite, the small white cocoons which the larva spins on the leaf being generally found throughout the attack. The ovipositor is inserted into the caterpillar during oviposition and the larva emerges when it is full grown, pupation taking place under the shrunken body of the caterpillar. The head and thorax of the adult are black, the abdomen being dark brown with yellow patches on the sides anteriorly. Antennae dark brown. Prothoracic and mesothoracic legs yellow, metathoracic legs brown. Length 3 m/m. Cocoon 3 to 4 m/m long and 1.5 m/m broad.

Chalcidoid No. 1086. Head, thorax and first abdominal segment brown. Eyes pink. Legs and antennae light yellow. Abdomen yellow, banded with light brown. Length 2 to 2.5 m/m.

Chalcidoid No. 1089. A. Head and thorax black, abdomen dark brown. Antennae long, moniliform, with long hairs arising from each segment. Legs brown, becoming lighter towards the distal ends. Abdomen contracted.

Chalcidoid No. 1089. B. Metallic shiny-black in colour. Abdomen pointed. Legs and antennae dark brown but the tibiae light coloured, almost white.

Nos. 1090 and 1358. Only one specimen of each of these has been obtained and they may be the same as one of the others mentioned. Specimens at the British Museum.

Ptychomyia remota Ald. sp. nov. This is the common Tachinid parasite which has only just been named by Dr. J. M. Aldrich of the U.S. National Museum.

Tachinid No. 1574. Two specimens have been taken recently. They differ largely from the common Tachinid, and may be recognised by being entirely black with smoky wings.

Tachinid No. 1685. A single specimen of this insect was taken. It is apparently different to both the other species. Specimen at British Museum.

Relative Importance of Parasites.

In the writer's opinion only one of the above parasites is really important in controlling outbreaks of *Artona catoxantha*, and that is *Ptychomyia remota*. On the other hand one or more of the Hymenopterous parasites may be the controlling insect which, by dying off at intervals, allows the moths to increase without restraint. The greater susceptibility of Hymenopterous insects to changed conditions, and especially of Chalcids, leads one to believe that these parasites play the important part in keeping the moth under control during 'normal' times. When the moth has once broken away, however, the Hymenopterous parasites seem incapable of catching it up and again placing it under control, the Tachinid always having been mainly instrumental in affecting this in all cases seen by the writer. Lewton-Brain (7) however, records that in 1923 an outbreak was finally controlled by an Ichneumonid, but no statistical evidence is available to show to what extent the various Ichneumonids co-operated.

In an outbreak at Lenggong in 1924 no Hymenopterous parasites were found, the Tachinid being the only parasite present. Taking the average parasitisation for 19 counts at different stages in various localities, the Hymenopterous parasites are present to the extent of 1.2% where the Tachinid is present to the extent of 10%. In no case so far has the percentage parasitisation of the Hymenopterous parasites been observed to be over 10%, while 50% and 60% for the Tachinid is not uncommon. At Sungei Ayer Tawar in 1924 the Tachinid parasitised over 45% of the caterpillars in the brood before the attack ceased. No figures are available at present to show the rate of increase in parasitisation and the rate varies enormously from palm to palm and even from leaf to leaf, so that nothing accurate can be given until considerable statistical work has been done. Enough has been said to show, however, that in all the outbreaks observed the Tachinid, *Ptychomyia remota*, is the most important parasite.

Ptychomyia remota, Ald.

On the assumption that it was the most important of the parasites on *Artona catoxantha* this species was studied when material was available.

History.

This Tachinid parasite has long been associated with outbreaks of this pest but has only recently been described from material sent to Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, who kindly sent it on to Dr. Aldrich (17). *Ptychomyia remota* is nearly related to *P. selecta*, Mg. of Europe.

Distribution.

As far as is known this Tachinid is distributed over the greater part of the area where *Artona catoxantha* is found, but was not present

in Labuan at the time of the second outbreak, in 1924. An attack was in progress at Lenggong, F.M.S., at this time, and several hundred pupae were collected and taken to Labuan, where they were released as adults. The time taken on the journey to Labuan being only five days it was possible to take the pupae without subjecting them to any special treatment. (Gater (15)).

Life History.

The adults emerge at approximately the same date as the moths of *Artona Catoxantha*. As will be seen later their adult life must be of some length to compensate for their short period of development and the longer period taken by the succeeding brood of their host. In the laboratory, however, the adult life proved to be shorter than was expected, averaging 10 days. This short life was undoubtedly due to improper feeding, a point which will be touched on again in relation to breeding the fly in captivity.

In several instances however, especially among the individuals which laid fertile eggs, the length of the adults' life was prolonged to three weeks, and in one instance a female lived for 27 days. Copulation took place on the same day or on the day following emergence, eggs being laid in from 3 to 8 days after copulation. In one instance the female laid no eggs for thirteen days after copulation. The number of eggs laid by a single female varied greatly, the average being between 25 and 30, but in one case 80 eggs were laid during a period of six days, the number on successive days being as follows:—8, 26, 21, 5, 14, 6. The male died soon after copulation and repeated copulation was not observed under laboratory conditions. The female generally died a short time, one or two days, after the cessation of egg-laying.

The egg is laid on the dorsal surface of the caterpillar, generally on the thoracic segments immediately behind the head, but may be laid on other portions of the body. As many as 8 eggs have been observed on a single caterpillar, although this is rare, there generally being only one. In cases where several eggs are deposited on the same caterpillar only one larva develops. The egg is longer than broad, convex on the upper and flat on the lower surface, where it is attached to the caterpillar. Parasitised caterpillars are generally found in groups, the fly laying eggs on a number of larvae close together and then going on to another group. There seems to be a reluctance to pick out isolated caterpillars. Hatching takes place two days after the egg is laid, the minute maggot emerging from the lower surface and making its way into the caterpillar through the thinly chitinised area between the segments. The maggot remains within the caterpillar until the latter has spun its cocoon in preparation for the pupal stage. When the cocoon is finished the maggot emerges and pupates, the puparium and the shrunken caterpillar's skin being found under the cocoon even long after the fly has emerged. The period between pupation and emergence is 9 days or the same as that

of the moth. The life history is summarised in the following table:—

LIFE HISTORY OF *PTYCHOMYIA REMOTA*

Period.	Range: Days.	No. of cases observed.	Mean: Days.
Emergence to Copulation	1 — 2	228	1
Copulation to Oviposition	3 — 8 (13)	45	4·5
Incubation of egg	2 — 3	49	2
Larval life	8 — 16	169	9
Pupal life	8 — 11 (16)	679	9
Total life of Imago (3)	5 — 27	228	10*

Figures in brackets denote isolated instances not taken into account in calculating means.

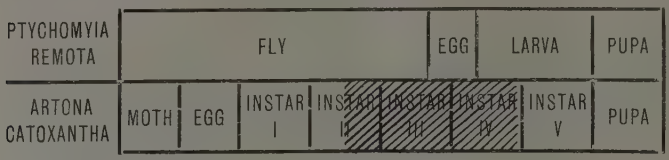
*This figure represents the mean for egg-laying individuals only. Barren females died in one or two days after emergence and have not been included.

Comparing the time taken for the development of the parasite with that of the host it will be seen that the parasite's development is 17 days shorter than that of the moth.

Ptychomyia remota apparently does not as a rule lay eggs until the larvae of its host have attained their third instar, which occurs 14 days before the moth's pupal stage is reached. Eggs may certainly be found in nature on younger caterpillars than those of the third instar, but only rarely and when mixed broods are present. As a rule eggs are not found on any but the caterpillars of the last three instars. From the available figures on the life history of *catoxantha* it is evident that the adult Tachinid must live from the time of its emergence, at approximately the same time as its host, until the latter has laid eggs and the eggs have developed to larvae of the third instar, before eggs are laid. This period is 15 to 20 days. Periods as long as this were not usual in laboratory, but enough instances of an adult life of 20 or more days were observed to justify the conclusion that the normal life is as long as this, and the longer life was especially noticeable in strong egg-layers. The readiness with which the flies copulated soon after emergence indicates that the waiting period is between copulation and laying. This is supported by the figures obtained in the laboratory which show a period of four to five days between copulation and laying, although caterpillars of the right age were present in the cage. The longest time between copulation and laying observed was 13 days, so that no experimental evidence is available to prove that the fertilised females will live for a period of 20 days without laying. But in the laboratory, as stated above, caterpillars of the correct age were available. There was no opportunity of testing the length of life of a fertilised female before laying. In the following figure* the mean life histories of the host and its parasite are

*In the original diagram the stages in the life-history were plotted according to the mean periods, but in the reproduction the proportions have been lost. The figure is, therefor, graphic only, the distances between the vertical lines not representing the actual length of each instar.

placed side by side, the periods during which eggs are most frequently laid by the parasites being shaded. It will be seen that the normal instars on which eggs would be laid are instars III and IV. The actual time of oviposition as shown in this table, calculated on the mean, is just before the moult between instars III & IV, which would mean that the caterpillars would moult and get rid of the egg before it had hatched. This actually occurred in many of the breeding experiments, but in nature oviposition would normally occur earlier in the 3rd or just after the 4th instar had appeared.



Alternative Hosts.

At the beginning of an outbreak *Ptychomyia remota* is not present in large numbers, and sometimes cannot be found until after one or two broods have taken place. It was thought that it might not be specialised to one host and that it might merely develop largely during the outbreak owing to the stimulus of an unlimited supply of suitable hosts. In addition to this the fact that the pupae have never been seen in normal times, even in old *catoxantha* areas, suggested that its normal host might be some other caterpillar.

Breeding experiments were therefor undertaken with several caterpillars, and as none was available which was nearly related to *Artona*, caterpillars of other families were used. Eggs were laid freely on the larvae of *Setora nitens*, Wlk. (Limacodidae) *Attacus cynthia*, Dru. (Saturniidae) the Pyralids *Tirathaba* sp. nr. *trichogramma*, Meyr., *Psara bipunctalis*, F. and *Maruca testulalis*, Hb., as well as the Banana Skipper, *Erionota thrax*, L. In numerous trials the eggs, however, failed to hatch.

Greater success was obtained with the larvae of *Achaea janaia*, L. (Noctuidae) and of *Sylepta derogata*, F. (Pyralidae) In both the latter the life history was completed several times from adult to adult, but only a very small percentage of the eggs laid hatched and completed their development. It has thus been shown that *Ptychomyia remota* will breed on caterpillars differing greatly from its known host, and that it shows a tendency to breed on many more. In releasing parasites for the control of this pest there is every hope, therefor, that the Tachinid will be capable of living in considerable numbers during the times when the host is present in very small numbers only.

Natural Enemies.

During the various experiments conducted with *Ptychomyia remota* a considerable number of hyperparasites was discovered, as

many as seven being probably different while two others may form an addition to the total number.

The hyperparasites are presumably all parasitic on the pupae of the fly and emerge some little time after the adult fly should have emerged. The following rough description may serve to separate them from one another for purposes of record :—

Chalcidoid No. 1335. Dark brown; antennae clubbed and elbowed, seven jointed. 1.2 m/m in length.

Proctotrypid No. 1383. Black with blue and green metallic lustre Wings smoky. Hind tibiae with light coloured keel on outer (dorsal) edges. Ovipositor long. Length 5.5 m/m including ovipositor, 4.1 m/m without.

Proctotrypid No. 1384. Black, metallic. Legs brown but mesothoracic and metathoracic tarsi white proximally. Length 2.5 m/m.

Chalcidoid No. 1497. Head and thorax black, strongly punctate; abdomen black, shiny. Antennae dark brown, moniliform, with hair at each segment. Coxae large. Trochanters, distal ends of femora, tibiae and tarsi yellow. Eyes pink, coarsely granulated. Length 3.3 m/m.

Chalcidoid No. 1594. Smaller than No. 1335 ; black with brown legs. Funicle of antennae not so long as in No. 1335. Head larger in proportion to rest of the body. Length 0.9 m/m.

Chalcidoid No. 1746. Head and thorax black, strongly punctate. Eyes finely granulated. Abdomen shiny black, pointed. Tibiae and tarsi lightening in colour from brown to white distally. Length 4 m/m

Chalcidoid No. 1747. Head and thorax black, strongly punctate. Abdomen black, shiny, segments fringed with short hairs. Hind femora much enlarged. Tegulae, distal ends of femora, tibiae and tarsi light yellow. Length 3.2 m/m.

Hyperparasite No. 1807 is a single specimen now at the British Museum and No. 1808 is similar to but smaller than No. 1746.

The Chalcidoid No. 1594 has been observed to emerge in large numbers from the puparia of its host, the lowest being 13 while the largest number found to have emerged from a single puparium was 82. The average number is 39. There has been no opportunity up to the present for studying the life history of these hyperparasites, but as a rule they do not emerge from the puparium until after the time when the Tachinid should have emerged. This has an important bearing on the technique required for introducing *Ptychomyia remota* into other countries where *catoxantha* or nearly related insects are damaging coconuts, since the introduction of the hyperparasites as well would tend to defeat the usefulness of introducing the Tachinid. As it is, careful records of the probable

time of emergence of the fly should be kept and any which show a tendency to prolong the pupal period should be specially watched and kept in cages which would prevent the minute hyperparasites from escaping. This does not apply to all the hyperparasites, some of which emerge at about the same time as the fly. Recorded instances give the emergence of No. 1497 as 3 days after unattacked flies of the same batch, No. 1594 as six days after and Nos. 1479 and 1508 as 8 and 13 days after respectively.

Resistance to low temperatures.

With a view to transporting *Ptychomyia remota* over long distances keeping the pupae in cold chambers was attempted. In the case of mature pupae, from which the flies were almost due to emerge, the low temperatures seemed to have little effect, the flies emerging in the ordinary way a day or more after having been placed in cold storage. The immature pupae were killed at temperatures of 5°.C. and 10°C. in two weeks. Through the courtesy of Messrs the Singapore Cold Storage Co. Ltd. a batch of pupae was then placed in a chamber where the temperature was kept between 13°.C. and 14°C. but all were again killed in a month.

These experiments were only started at the end of the outbreaks of *catoxantha* in 1924 and so could not be continued. The negative results of treatment by cold thus obtained show that the exact conditions under which this insect may be kept dormant must be ascertained before any attempt is made to transport it over long distances. It is intended to construct a multiple temperature incubator, with which it should be possible to find the optimum temperature for the development of the insect and also the death points at each end of the scale. It is possible that by keeping puparia of the correct age at a temperature slightly below the mean daily temperature in the open air, they may be kept in a dormant condition for long periods.

Entomophagous Fungus.

A fungus, *Botrytis necans*, Massee, attacks the later larval and pupal stages of *Artona catoxantha* apparently causing the death of considerable numbers. It appears to have been first observed by Burkill (9) in 1913 and was described by Massee in the same year. On this occasion and again in 1915 Burkill (10) states that *Botrytis necans* stopped the attack. It is only rarely that a good infestation by this fungus can be seen, but attempts have been made to control outbreaks by hanging up leaves of palms from another area where the pupae were attacked by the fungus, with varying success. In this laboratory pure cultures prepared by the Mycologist (A. Sharples) have been used on healthy caterpillars and pupae with negative results, and spraying caterpillars under natural conditions with the cultures has also given negative results.

The well known difficulty of propagating fungous diseases among insects artificially is probably responsible for the lack of success in these experiments. On the other hand it is not always certain that the fungus can be recognised in the field, and pupae said to be

infected with it have developed to normal adults in this laboratory. During the 1924 outbreak at Sungei Ayer Tawar, where fungus infestation on dead caterpillars was between six and seven per cent, a number of larvae and pupae were taken to the Mycologist, who reported that the fungus present was not *Botrytis necans*, but a collection of saprophytic fungi which are normally found on dead larvae. This indicates that where dead larvae or pupae are found too much reliance may be placed on the fact that they were killed by *Botrytis necans*. The reason of the death of such caterpillars has yet to be sought, however, and two possibilities seem feasible. Either they are first killed by the *Botrytis*, which is then obscured by the growth of other fungi, or the caterpillar had died from the affects of an internal insect parasite which, although it had killed the caterpillar, had not itself been able to develop. In many infestations of *catoxantha* the cocoons are often spun so close to each other that the ends frequently overlap. At Pulo Kuraman it was observed that in many cases the moth had partially emerged inside the cocoon and died, whereas the invariable habit of this insect is to open the cocoon in the pupal stage, the moth emerging after the pupa has half extruded itself from the cocoon. It thus seems probable that a good many die through not being able to emerge from the cocoon, though to what extent this is true appears doubtful.

That considerable success has been attained by spreading the fungus appears from Burkill's (9) report on the outbreak at Singapore. He states that the percentage of parasitisation by Tachinids and Braconids was only 5 per cent in the brood when measures for spreading the fungus were taken. Distribution of the fungus was effected by taking portions of coconut leaf whereon caterpillars or pupae had died from the fungous disease and tying them to the leaves of trees where healthy caterpillars were feeding. In the next brood the attack was killed out. According to South (14) an attack at Telok Ayer Tawar in Province Wellesley decreased in severity owing to parasitisation by the fungus. Leaves well infested with caterpillars killed by the fungus were taken from this area to Menglembu, where another attack was in progress, with satisfactory results. As long ago as 1914 Jepson imported cultures of *Botrytis necans* into Fiji in an attempt to control *Levuana iridescens*, and it has been imported on several occasions since. No satisfactory results seem to have been achieved however.

Although the artificial propagation of this fungus by cultures has not met with success in any instance, this method of control should not be dismissed in view of the success said to have been obtained by the distribution of the leaves bearing fungus-infested caterpillars, and the method should be kept in mind as a possible control measure. More work on the fungus is necessary before success can be hoped for by using the cultures, and the fact that success is said to have been obtained by spreading the fungus artificially cannot be taken as evidence that such measures constitute a means of control. The fungus can always be found, and given the proper conditions will spread naturally. In the cases where great mortality from the fungus was observed after measures for its spread had been taken, it is more than

probable that it would have caused just as great a mortality had it not been 'spread' artificially.

Meteorological Influences.

For some time it has been thought that meteorological influences might be responsible for the sudden appearance, and what is more, the sudden disappearance of this pest. A large number of meteorological records has been examined, but during the past it is feared that the records were not sufficiently accurate to enable any definite conclusions to be arrived at. Many of the thermometers were insufficiently graduated, and in addition humidity readings were generally taken in a partially enclosed space with little air circulation, which would produce inaccurate results in a climate such as this.

Further, readings were not taken beyond a whole degree, which makes the humidity records too unreliable to be of any use. Atmometers do not exist as part of the equipment in this country, and even if they did the calibration of the instruments would present difficulties. It is therefor not possible to use any records except those of the mean daily temperature and rainfall, both of doubtful accuracy.

As far as the cessation of an atlack is concerned there seems to be some connection with rain and wind, since several attacks have been known to stop without any other reason, as far as could be seen, than the start of rainy and windy weather or the breaking of a monsoon. It is doubtful if rain alone has much affect, but in combination with wind it would kill a large number of larvae. A strong wind beating on the leaves of the palms would tend to make the larvae drop down on their silken threads, and the rain would then wash a large number away or so damage them that they would be unable to reascend the palms. That some definite meteorologic influence is at work appears to be probable from the incidence and cessation of two similar outbreaks which occurred at Pulo Kuraman. The first recorded outbreak occurred there in April 1920 (the caterpillars were first noticed in the middle of the month) and ended suddenly at the beginning of June of the same year. The second outbreak occurred in May (the caterpillars being first noticed on May 5th) and ended on July 25th, 1924. The fact that during the second outbreak the planters were already acquainted with the pest, and would observe it more quickly and accurately tends to place the dates still nearer together. The disappearance in each case corresponded with the breaking of the monsoon. This sensitiveness to wind has been noted on several occasions, and it was most noticeable at Pulo Kuraman where a belt of palms was left untouched to windward of the area. As soon as the monsoon broke the moths and caterpillars rapidly disappeared.

The beginning of an attack might be influenced by a variety of weather conditions, but nothing definite has been found out. The meteorological stations have always been situated at some distance from the area under consideration, and owing to local variations in readings any results must be accepted with caution.

Meteorological Data.

Rainfall (m/m).

Pulo Kuraman.	1919	1920	1923	1924	
January ...	34	298	236	77	Outbreaks occur-
February ...	47	23	175	68	red in
March ...	221	180	105	258	1920 and 1924.

Batu Gajah.	1921-2	1922-3	1923-4	
December ...	113	470	90	The outbreak occurred
January ...	308	251	241	in 1923 at
February ...	131	272	89	the end of February.

Total Temperatures (°F).

Pulo Kuraman.	1919	1920	1923	1924
January ...	2562	2500	2513	2533
February ...	2289	2283	2200	2399
March ...	2567	2537	2522	2568

Batu Gajah.	1921-2	1922-3	1923-4
December ...	2546	2457	2510
January ...	2532	2476	2532
February ...	2292	2293	2239

The nearest meteorological station to Pulo Kuraman was at Labuan, about 4 miles away. Records were obtained from Batu Gajah, where the station is much nearer the area, and are more representative of the conditions obtaining there. The accompanying table shows the rainfall at Pulo Kuraman (from Labuan records) and at Batu Gajah, and also the total mean daily temperatures for the same areas. In each case the date on which the caterpillars were first noticed was taken and the records used for the three preceding months. It is not possible to say definitely whether these months formed the critical periods during which the moth broke away from its parasites, since it is not exactly known at what brood the caterpillars were first seen. If it is assumed that they were not noticed until the second brood then the break-away would be during that period. In January 1920, the year of the first outbreak at Pulo Kuraman, the rainfall was considerably higher than in the preceding year, yet in 1924, the year of the second outbreak, it was lower than in the preceding year. At Batu Gajah the December records for the last outbreak in 1923 show a considerable excess of rainfall over the amount for the preceding and following years.

Charts of the daily mean temperatures for both areas show nothing definite, and the total mean daily temperatures for the months in question appear to shed no further light on the subject in

view of the contradictory figures for two outbreaks in Pulo Kuraman. At Batu Gajah on the other hand the figures are more constant, but the difference in totals is so small that no inference can be drawn from them. One point in the temperature records is, perhaps, worthy of note, and that is the occurrence of "abnormally" low temperatures during the months preceding the outbreaks. Thus during the first two months quoted, 75°F. is recorded twice in Pulo Kuraman in 1920, with a temperature of 73°F. on one occasion, and once in 1924. During 1919 and 1923 the lowest recorded temperature is 76°F. At Batu Gajah in 1922-23 there are 21 records of 75°F., 9 of 74°F. and 1 of 73°F., whereas during the corresponding periods in 1921-22 and 1923-24 there are only 9 records of 75°F. which was the lowest temperature recorded. The mean daily temperatures for the periods being close to 81°F. and varying little, as is natural in Malaya. Further records for Batu Gajah could not be studied because the times at which the pest was first seen could not be ascertained with any degree of accuracy. No conclusion can be arrived at until further accurate records become available.

CONTROL.

Various control measures have been suggested for this insect, none of which can be claimed to have been a great success. One of the commonest practices is to cut off all the more heavily infected leaves and burn them. Apart from the injury done to the palms by this treatment and the danger incurred from the wounds which would be certain to be left if this was done over a large area, and in which the palm weevil (*Rhynchophorus schach*, Oliv.) would be able to lay its eggs, it never stops the attack entirely, and has the disadvantage of killing large numbers of parasites. On one estate where this practice was started as soon as the caterpillars were noticed the attack lasted for a much longer time than usual, and spread over a greater area than had been noticed in other outbreaks. Spraying with lead arsenate and kerosene emulsion has also been advocated, as has also burning under the trees to create a "smudge" and singeing the caterpillars by means of long torches. All these methods have the common disadvantage that they destroy the parasites as well as the pest, and in the case of burning under the palms to produce a "smudge" the smoke seems to have very little effect. In view of the apparent connection between burning under trees and the incidence of an attack, the latter method would also appear to be dangerous. If left to themselves the parasites eventually assume control, and any method, therefor, which kills the parasites is to be condemned, In view of the fact that the principle parasite, *Ptychomyia remota*, rarely oviposits on young caterpillars, it is possible to kill the caterpillars in their early stages without damaging this parasite if spraying is done at the right time. Spraying on coconut trees is very rarely an economic proposition, even if the palms are short. On tall palms it is rarely possible, and the spraying apparatus necessary for use with tall palms is not only not available in Malaya, but would be very difficult to move about on some of the coconut estates. If spraying can be accomplished, a spray containing 2 lbs. of powdered lead arsenate in 100 gallons of water with the addition of one of the common spreading agents, and used as soon as the second instar larvae appear, would stop an

attack if started during the earlier broods. In any case, much good would be done in the later broods of an attack by this method without harming the parasites, all of which would have emerged by the time the second instar had appeared. This method is, however, of small practical value on coconut estates, and would require careful supervision for its correct application. In one case at Batu Gajah the fire engine was obtained by this Department, and a strong jet of pure water played on the leaves bearing the early stage caterpillars. The fire engine was only employed for a short time, but the results were eminently successful, the larvae being beaten down in thousands. They were then collected by children, but the majority seemed unlikely to survive the buffeting they received from the water. The cost of the fire engine worked out at Straits $5 per acre including everything, and on tall trees 4 acres were "sprayed" a day. A powerful pump like a fire-engine would not be required in estate practice, but a small power pump capable of throwing a strong jet of water would be a useful means of combatting the pest. On estates this method would, of course, be limited by the facilities available for moving the pump from place to place, and the proximity of a sufficient water supply. The idea of merely knocking the caterpillars off the leaves prompted the use, some time ago, of bamboo poles with which the leaves were agitated. This method is laborious and not as efficient as the jet of water. Banding the palms could be used to prevent the caterpillars reascending the trunks.

The introduction of parasites in large numbers from other areas is a feasible method of shortening the attack, and if parasites are numerous boxes could be employed which release the parasites but retain the moths by means of wire gauze. This necessitates the removal of some leaves, preferably the lowest and most highly infected, care being taken to cover up any wounds made by their removal. This again is not always an entirely feasible method on a large estate owing to the number of boxes which would have to be provided, but if used in the early stages of an attack parasite boxes would materially help in making the attack of short duration.

The introduction of the fungous parasite has been advocated, but as already mentioned in dealing with *Botrytis necans* the results have been so contradictory that no positive recommendations can be made. Tying portions of leaves bearing caterpillars or pupae which have been killed by the fungus to the leaves bearing healthy caterpillars appears to have had some success, but the fungus is always present and will spread naturally if the conditions are suitable.

One method of controlling outbreaks which would be extremely effective would be by breeding large numbers of the parasites and keeping them in a dormant condition ready for release in the infected areas. It has been shown that *Ptychomyia remota* can be bred on two caterpillars differing widely from *Artona catoxantha*, and that it will lay eggs on a great many more. Breeding in the laboratory was not however, successful from the point of view of numbers, owing to the large numbers of infertile eggs which were produced. It is believed that this is entirely due to improper feeding of the adult flies. It has been shown by Glaser (16) and others that food is an important

factor in the oviposition and fertility of *Musca domestica* and other flies, and there seems to be little doubt that the same applies to Tachinids. This must however, form the subject of another investigation, and until more is known about the food factors influencing the fertility of *Ptychomyia remota* breeding it in large numbers is not possible, nor is it certain that they could be kept dormant for long periods. Other caterpillars were tried owing to the difficulty of breeding *A. catoxantha* in capitivity. The life history of the Tachinid on *Achaea janata* and *Sylepta derogata* took from 16 to 26 days with a mean period of nearly 21 days and is thus comparable in time with that of the normal host. The adults were fully developed and no differences could be seen between those which developed on the normal and "artificial" hosts.

Only by a close study of the life-history of the moth and the relation of its various parasites to it, and of the influence of the hyperparasites, will any satisfactory control measures be devised. On very large areas dusting by aeroplane is a feasible control method if done in the early stages, but such methods are too advanced for use in this country at the present time. In the imperfect state of our knowledge the following recommendations are made:—

1. No burning of rubbish or other material under the coconut palms to form any part of estate practice.

2. Spraying, if possible, as soon as the second instar caterpillars have appeared, to be stopped as soon as the third instars have appeared.

3. The use of a strong jet of water supplemented by banding during the same period as for spraying

4. No action to be taken which will kill the parasites, such as cutting and burning or late spraying.

5. Release of parasites without the moths by the use of parasite boxes. The lower leaves, which would be the most heavily infected, could be used for this purpose.

SUMMARY.

1. *Artona* (*Brachartona*) *catoxantha*, is an important pest of coconuts in Malaya and surrounding countries. It appears at uncertain intervals in enormous numbers.

2. An attack of moderate severity results in the loss of about a year's crop, but the palms are not killed outright.

3. The life history takes 5 to 6 weeks. Eggs are laid singly on the underside of the pinnae. The larvae feed on the epidermis of the underside of the leaves in straight lines, giving typical feeding marks. The later stages may eat the edge of the leaves. Pupation takes place on the leaf in flat oval-shaped cocoons.

4. Attacks have always been controlled by parasites, five to six broods taking place before this is accomplished.

5. Nine Hymenopterous parasites, three Tachinid parasites, a predaceous Clerid and an entomophagous fungus have been discovered on the larvae.

6. The most important parasite appears to be the Tachinid, *Ptychomyia remota*. The life history of this parasite takes 20 days and it is attacked by 7 hyperparasites.

7. *Ptychomyia remota* has been bred on the caterpillars of *Achaea janata* and *Sylepta derogata*. Efforts at keeping the pupae in cold storage have so far failed.

8. No definite meteorological influences can be found, but the cessation of attacks where the parasites are not abundant has coincided with the breaking of a monsoon. It is thought that strong winds are detrimental to the caterpillars.

9. There appears to be a connection between the occurrence of outbreaks of the pest and the practice of burning rubbish under the palms.

10. *Ptychomyia remota* has been introduced into an area for the control of this pest, but breeding it in large numbers has so far not been successful.

11. Control measures suggested are the cessation of burning under the palms as part of estate practice ; the use of a lead arsenate spray, or a strong jet of water supplemented by banding during the first, and early stages of the second, instar ; and the release of parasites by the use of parasite boxes.

LITERATURE CITED.

1. 1892. Hampson, G. F. Fauna of British India, Moths Vol : 1 p. 233. London.

2. 1904. Ridley, H. N. Agric : Bulletin, S.S. & F.M.S. New Ser : Vol : III, No. 3.

3. 1907. Pratt, H. C. Agric : Bulletin, S.S. & F.M.S. New Ser : Vol : IV No. 9.

4. 1908. Jordan, K. Seitz, Macrolepidoptera of the World, Vol : X pp. 42 & 44. English Edn , Prout.

5. 1908. Königsberger, J. C. Bull : Dépt : de L'Agric : Indes Néerlandaises, Vol. 20 No. 3. Buitenzorg.

6. 1909. Pratt, H. C. Dept : Agric : F.M.S. Special Bulletin No. 4.

7. 1913. Brain, L. Lewton. Dept : Agric : F.M.S. Special Bulletin No. 18.

8. 1914. Roepke, W. Meded. Proefst. Midden Java No. 18, Batavia.

9. 1914. Burkill, I. H. Gardens Bulletin S. S. Vol: I. No. 7, p. 207. Singapore.

10. 1916. Burkill, I. H. Ann: Report, Dir: of Gardens S.S. for 1915. Singapore.

11. 1917. Richards, R. M. Agric: Bulletin, F.M.S. Vol: V, No. 8-9, p. 335.

12. 1920. Corbett, G. H. and South, F. W. Agric: Bulletin F M.S. Vol: VIII, No. 2, p. 107.

13. 1921. Van Heurn, W. C. Ent. Ber. Ned. Ent. Vereen, Vol: VI, p. 122. The Hague.

14. 1921. South, F. W. Agric: Bulletin, F.M.S. Vol: IX, No. 3, p. 203.

15. 1924. Gater, B. A. R. Malayan Agric: Journal Vol: XII. No. 11, p. 374.

16. 1924. Glaser, R. W. Jour. Econ. Ento. Vol; 17 No. 4, p. 486. Geneva, New York.

17. 1924. Aldrich, J. M. (At the time of writing this reference was not available, but Dr. Aldrich wrote me to the effect that the description would be published in the Proc: of the Ento: Soc: of Washington, in the December or January (1925) number. B.A.R.G.)

ILLUSTRATIONS.

(About natural size)

The accompanying illustrations are included as a guide to planters and others who may not be acquainted with the different stages of *Artona catoxantha*. No illustrations of this insect have been published in Malaya, the only available ones being in Dutch publications which are not always readily available.

Fig. 1. Larvae.

Fig. 2. Pupae, a. Newly formed.
b. Just before emergence.

Fig. 3. Cocoons on leaf.

Fig. 4. Cocoons showing empty pupal cases projecting.

Fig. 5. Adult. a. Male.
b. Female.

Fig. 6. Attitude of moths while resting.

Received for publication 24th March, 1925.

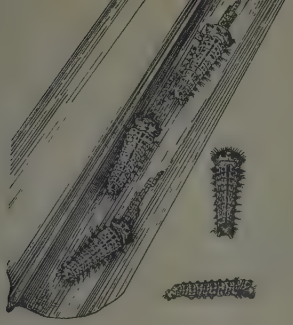


Fig: 1

Fig: 2

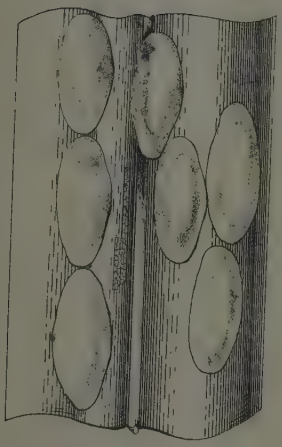


Fig: 3

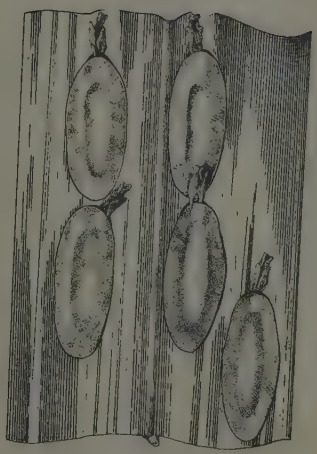


Fig: 4

a

b

Fig: 5

Fig: 6

J. Anthony

FIBRE INVESTIGATIONS.

IN connection with investigations on fibres, particularly Sisal hemp, Pineapple fibre and fibres from plants allied or similar to the Arghan Fibre plant, the following reports from the Imperial Institute and from various dealers in Australia on fibres prepared at the Department of Agriculture are published for information.

Sisal Hemp.

An article on Sisal hemp was published in this Journal Vol. XII, No. 11, 1924.

A sample of the fibre prepared at the Department of Agriculture from plants grown at the Experimental Plantation, Kuala Lumpur (planted 1914 and cut 1924) was submitted to the Imperial Institute and the following report on the sample has been received :—

> " The sample consisted of a bundle of coarse, lustrous, cream-
> " coloured fibre well cleaned and prepared. The staple varied
> " from 2 feet 10 inches to 4 feet 3 inches with an average of
> " 3 feet 6 inches. The strength is described as good.

Results of Examination :—An investigation of the fibre yielded the following results.

	Sample examined at Imperial Institute.	Sample examined at Department of Agriculture.
Moisture -	11.8 per cent.	13.3 per cent.
Ash -	0.5 ,, on dry fibre.	0.9 ,,
Hydrolysis "A" Loss -	10.4 ,, ,,	12.0 ,,
,, "B" ,, -	12.4 ,, ,,	14.0 ,,
Acid Purification -	1.3 ,, ,,	1.3 ,,
Water washing -	1.1 ,, ,,	Trace ,,
Cellulose -	77.1 ,, ,,	78.2 ,,

The results indicate that the fibre is of excellent quality, especially as it suffers comparatively small losses on treatment with dilute alkali (hydrolysis) and acid treatment and contains a high proportion of cellulose.

Commercial Valuation :—Consignments of fibre of similar quality would be readily saleable in London at a price equivalent to the best East African grades, which are quoted (Nov. 1924) at £50 per ton.

(Remarks :—The plants from which this fibre was obtained had not been cut regularly and were about 10 years old. The average weight of a leaf was 0.8 lb., length 3½ feet and breadth 4 inches. The yield of fibre on the fresh green leaf was 5 per cent. B.J.E)

Report from Australia.

The following reports from various dealers in Australia to whom samples of Sisal hemp prepared at the Department of Agriculture were sent are also of interest.

Firm A. Melbourne:—The sample is of fair length and fair quality, but the colour is not equal to Java "A" Sisal. It is a commercial article and at the moment we value it at from £45 to £48 per ton *c.i.f.*

Firm B. Melbourne:—The Sisal sent is only fair quality, being rather short side and lacking in lustre and sheen. Commercially this fibre is not equal to Java Sisal. On today's market the value would be about £48 per ton at Melbourne.

Firm C. Melbourne:—The Sisal is not up to the Java Sisal which we import. The length is certainly good but in its present state we would not call it a high grade fibre on account of it not being cleaned properly. It is used largely in Australia for the manufacture of cords and also for the Fibre Plaster Sheets manufactured. No value was quoted, but the firm asked for quotations.

Firm D. Perth:—The sample is not as good quality as the Java Sisal owing to (1) its harshness in texture. (2) poorer colour. The length of the fibre is fairly good and sufficiently long for our purposes. The value of the fibre is about £37—£38 per ton *c.i.f.*, Freemantle. The fibre should be pressed in tightly packed bales of about 5 cwt. each.

Firm E. Perth:—The quality is very fair. We understand this hemp is chemically bleached, your sample is not as evenly bleached as we would like. There must not be any green strands left in the stuff for our work (Note:—None of the samples had been chemically bleached. In Java, the fibre is sun-bleached and it is probable that the washing, brushing and sun bleaching of these samples had not been carried out sufficiently B.J.E.)

The price of "A" quality hemp fluctuates from £35 to £45 per ton *f.o.b.* Freemantle.

Firm F. Brunswick:—It is an excellent fibre. The value is about £48—£49 per ton *c.i.f.*

It will be noted that the opinions expressed by the Australian dealers are somewhat varied, although the majority are of opinion that the samples are not up to the standard of the best Java Sisal. This however is probably due to the preparation, which can be improved by the use of more efficient machinery, further washing and sun drying.

Pineapple Fibre.

The sample of pineapple fibre reported on by the Imperial Intitutes was extracted from the leaves of plants grown by Mr. Goh Hock Huat

at Klang for fruit purposes. The leaves were cut from the plants after fruiting. The average weight of a leaf was 2¼ ozs., length 4 feet and breadth 1 inch. The fresh green leaves yield about 1 per cent. of dry cleaned fibre.

The sample consisted of a bundle of a fine, rather harsh, lustrous, pale cream-coloured fibre which was well cleaned on the whole but contained a few hard "runners." The strength is described as very good. The staple varied from 2 feet 6 inches to 4 feet 6 inches, with an average of 3 feet 6 inches.

Results of Examination:—The following results were obtained on investigation of the sample.

	Sample examined at Imperial Institute.	Sample examined at Dept. of Agric.
Moisture -	10.7 per cent.	9.7 per cent.
Ash -	0.7 ,, on dry fibre	0.8 ,,
Hydrolysis "A" Loss -	13.1 ,, ,,	14.7 ,,
,, "B" ,, -	17.9 ,, ,,	17.0 ,,
Acid purification ,, -	2.9 ,, ,,	2.2 ,,
Water washing ,, -	3.3 ,, ,,	0.9 ,,
Cellulose ,, -	78.6 ,, ,,	79.0 ,,

The results indicate that the sample is of good quality and fairly well prepared, but contains a slight excess of gummy matter.

Commercial valuation:—Pineapple fibre, owing to the difficulty of extraction, is not offered to any extent on the London market, but fibre of the quality of the sample would probably be saleable at about £50 per ton (Nov. 1924) if offered in commercial quantities.

(Note:—The Chemical Division has recently prepared about 3 cwt. of pineapple fibre from leaves obtained from plants growing at the Government Plantation Serdang, for despatch to the Belfast Ropeworks and the Textile Department of the Municipal College of Technology, Belfast, who have kindly offered to prepare and spin the fibre and convert and dye the yarn. A report on the results will be published later. B. J. E.)

Caraguata Fibre (Bromelia argentina).

A sample of fibre was extracted from leaves of the Caraguata fibre plants grown at the Government Plantation, Serdang.

The plants from which the fibre was obtained were planted in March 1923 and the leaves cut in October, 1924.

The average weight of a leaf was 2.2 ozs, the length 3½ feet and breadth 2 inches. Yield of fibre on fresh leaf: 1.5 per cent.

Results of Examination:—The following results were obtained on examination of the cleaned fibre:

	Sample examined at the Dept. of Agric.	Sample examined at the Imperial Institute.
Moisture	- 10.87 per cent.	10.9 per cent.
Ash	- 0.21 „ on dry sample.	0.4 „
Water purification loss	- 0.57 „ „	0.6 „
Acid „ „	- 0.69 „ „	1.8 „
Hydrolysis "A" „	- 16.98 „ „	16.0 „
„ "B" „	- 23.66 „ „	23.0 „
Cellulose	- 68.08 „ „	70.9 „

The following additional observations are included in the Imperial Institute report:—

The sample consisted of a white, fine, lustrous fibre, which was on the whole well cleaned and prepared, although a small amount of parenchymatous matter was still adhering in places. The fibre was strong and had a length of staple ranging from 24 to 44 inches, but mostly about 30 inches. The ultimate fibres measured from 1 to 3.5 mms in length with an average of 2.3 mms and 0.005 to 0.018 mms in diameter with an average of 0.012 mms.

The results of the two examinations are in close agreement and indicate the presence of a rather large amount of gummy matter, which is removed on boiling for five minutes with hot dilute alkali (hydrolysis A).

The true fibre substance appears to be fairly resistant to the action of alkali, as a further loss of only 7 per cent occurs after boiling for 55 minutes longer (hydrolysis B).

[NOTE:—The resistance however is certainly not as good as in the case of sisal hemp and pineapple fibre, in which the extra loss on "hydrolysis B" is only 2 and 4 per cent respectively. B.J.E.]

After allowing for the gummy matter, the percentage of cellulose is satisfactory.

Commercial Value:—The fibre was described by merchants in London, to whom it was submitted, as a soft fibre of rather dingy colour and short staple, well cleaned, of good strength and readily saleable in London at £36—£37 per ton (January, 1925).

The fibre is not suitable for spinning as a substitute for flax or other soft fibre of similar class but would find a ready market as a cordage fibre in competition with "Maguey" fibre (Agave Cantala-

=Sisal) and Indian "Aloe" fibre. A fibre of greater and more regular length is however desirable (It is probable that the leaves from which the fibre was extracted were immature B. J. E.)

Cultivation and Growth :—The following notes on the cultivation and growth of the plants have been prepared by Mr. J. N. Milsum, Ag. Agriculturist, S.S. & F.M.S.

The suckers were received from the Argentine in October 1923 and the plants, which were established in the nurseries, made rapid growth and were planted in the field without shade in March 1923. The planting distance subsequently adopted was 10 feet x 5 feet. The plants soon produced suckers which were used for further planting.

In May 1924 the maximum height of the original plants was 5 feet and average length of leaf 3½ feet, number of leaves per plant was 80, breadth of leaf 2½ inches and weight of green leaf 3 ozs. The plant grows well on ordinary soil and commences to sucker when a year old. It grows well in full sunshine. In this respect it differs from the Arghan Fibre plant (Bromelia Magdalenae).

The leaves are difficult to handle for fibre extraction owing to the presence of strong thorns along the edges.

The original plants, among other related fibre plants, were obtained from the Argentine, where they are indigenous, in order to compare the plants and the fibre with the Arghan Fibre plant introduced into Malaya a few years ago, probably from South America.

References D.A. 1136/21, 518/24, and 1061/24. A.C. 153/24 and 198/24.

B. J. E.

Convener. Fibre Committee.

Received for publication 20th April 1925.

LONDON MARKET PRICE LIST, 1st QUARTER 1925.

Oil Seeds.

Castor (Bombay)	-	£26.7.6 to £23	per ton.
Copra (Ceylon)	-	£31 to £30.10.0	,,
Do. (Straits)	-	£30.5 to £29.5	,,
Cotton (Egyptian)	-	£13.7.6 to £13.2.6	,,
Do. (Bombay)	-	£10.15.0 to £10.12.6	,,
Croton	-	27/6 to 32/6	per cwt.
Desiccated Coconut (fine)	-	38/6 to 38/-	,,
Do. do. (medium)	-	,,	,,
Do. do. (coarse)	-	43/-	,,
Gingelly (Chinese)	-	£27.12.6 to £25.5	per ton.
Groundnuts (Gambia, undecorticated)	-	£18 to £17.2.6	,,
Do. (Chinese, decorticated)	-	£23.15 to £22.7.6	,,
Linseed (Bombay)	-	£24 to £25.5	,,
Do. (Plate)	-	£21 to £22.7.6	,,
Palm Kernels (West Africa)	-	£22.7.6 to £21.2.6	,,

Oils.

Castor (Madras)	-	61/6 to 71/-	per cwt.
Do. (Pharmaceutical)	-	78/- to 66/-	,,
Do. (1st pressing)	-	73/- to 63/-	,,
Do. (2nd pressing)	-	71/- to 58/-	,,
Coconut (Cochin)	-	62/6 to 60/-	,,
Do. (Ceylon)	-	47/6	,,
Cotton seed (Egytian, crude)	-	46/6 to 45/-	,,
Do. (Bombay)	-	44/6 to 43/-	,,
Groundnut (Oriental, crude)	-	55/6 to 50/-	,,
Do. (English)	-	56/ to 49/6	,,
Linseed (Calcutta)	-	46/- to 48/-	,,
Do. (Plate)	-	45/- to 47/6	,,
Palm (Lagos)	-	£39/10 to £42.15	per ton.
Palm (Sumatra)	-	£36.2.6 to £36.5	per ton.
Palm Kernel	-	41/-	,,

Oil Cakes.

Coconut	-	£11.5.0 to £12.10	per ton.
Cotton (Egyptian seed)	-	£8.15 to £8.2.6	,,
Do. (Bombay seed)	-	£8.5 to £7	,,
Groundnut (decorticated)	-	£13 to £14	,,
Linseed	-	£13.2.6 to £14	,,
Palm kernel	-	£8.10 to £8	,,

Essential Oils.

Cajeput	-	3/3 to 2/11	per lb.
Camphor (Chinese, crude)	-	2/4½	,,
Do. (Japanese refined)	-	2/7 to 2/8	,,
Do. (oil)	-	59/6 to 61/-	per cwt.

Essential Oils—*contd.*

Cinnamon (Ceylon leaf)	-	4¼d. to 5d.	per oz.
Citronnella (Ceylon)	-	3/- to 2/11	per lb.
Do. (Java)	-	5/9 to 4/9	,,
Clove	-	7/3 to 7/9	,,
Lemon grass (Cochin)	-	4/10 to 5/1	,,
Lime (West Indian, expressed)	-	12/6 to 15/-	,,
Do. (do. distilled)	-	6/6 to 7/10	,,
Patchouli (Penang)	-	15/ to 15/9	,,
Vetiver (Bourbon)	-	48/- to 50/-	,,

Spices.

Capsicums (East Indian)	-	40/- 45/-	per cwt.
Do. (Nyassaland)	-	60/- to 70/-	,,
Chilhes (Zanzibar)	-	35/- to 40/-	,,
Do. (Nyassaland)	-	50/- to 60/-	,,
Do. (Japan)	-	149/- to 130/-	,,
Cinnamon (Ceylon)	-	1/7 to 1/4 per lb. according to quality.	
Cloves (Zanzibar)	-	1/- to 1/1	per lb.
Cloves (Penang)	-	2/6 to 3/-	,,
Ginger (Japan)	-	100/-	per cwt.
Do. (Jamaica)	-	120/- to 150/-	,,
Mace (Bombay and Penang)	-	3/- to 3/9 per lb. according to quality.	
Nutmegs (Singapore and Penang)			
110's	-	2/2 to 2/-	per lb.
80's	-	2/5 to 2/4	,,
64's—57's	-	2/6 to 2/8	,,
Pepper (Singapore, black)	-	5d. to 5½d.	,,
Do. (do. white)	-	9d. to 9½d.	,,
Tumeric (Bengal)	-	80/- per cwt. nom.	

Drugs.

Cinchona Bark	-	According to analysis Market steady.
Cocaine (hydrochloride)	-	22/6 to 24/6 per oz.
Ipecacuanha (Rio)	-	7/9 to 8/- per lb.

Natural Dyestuffs and Extracts.

Annatto (seed)	-	10d. to 1/-per lb. Nom.
Gambier (block)	-	70/- per cwt.
Do. (cubes)	-	120/- 95/- ,,

Gums & Resins.

Damar (Singapore)	-	30/- to 150/- per cwt.	
Do. (Batavia)	-	120/- to 160/- ,,	
Dragon's Blood (reeds)	-	£18 to £25 ,,	Nom.
Do. (lump)	-	£6 to £15 ,,	Nom.

Gums & Resins—*contd.*

Guttapercha (genuine)	-	2/9 to 6/-	per lb.
Do. (Sarawak)	-	3/- to 4/-	,,
Do. (Siak, reboiled)	-	10d.	,,
Jelutong	-	£30 to £60 per ton	Pressed 9d. per lb.

Fibres.

Cotton (American G. to Mid.)	-	11.57d. to 13.27d.	per lb.
Do. (Egyptian Sakellaridis, G.P. to fine)	-	29.40d. to 32.90d.	,,
Hemp (Manila, "J" grade)	-	£56 10	per ton.
Do. (Mauritius)	-	£45.10 to £48	,,
Do. (New Zealand)	-	£41 to £44	,,
Do. (Sisal)	-	£30 to £53	,,
Kapok (Indian)	-	11¼ to 11d.	per lb.
Do. (Java)	-	1/2¾ to 1/2½	,,

Foodstuffs.

Cocoa (Ceylon, plantation)	-	80/- to 120/-	per cwt.
Coffee (Malay Plantation)	-	110/- to 140/-	,,
Do. (do. Liberian)	-	105/- to 120/-	,,
Sago (pearl)	-	28/-	,,
Do. (flour)	-	17/6 to 18/6	,,
Sugar (Java, white)	-	30/9 per cwt.	
Tapioca (Penang, flake)	-	3½d. to 4d. per lb.	
Do. (Penang, flour)	-	18/- to 22/- per cwt.	

Chemicals.

Acetic acid (glacial)	-	£68	per ton.
Do. (80% comml.)	-	£41	,,
Acetone	-	£75	,,
Ammonia (.880)	-	£24	,,
Calcium acetate (grey)	-	£15 to £15.10	
Citric Acid	-	1/4½ per lb.	
Formic Acid (85%)	-	£49	per ton.
Formalin (40% vol.)	-	£44	,,
Lime Juice (concentrated)	-	£18.15 per ton	Nom. No sales.
Sodium bisulphite (60—62%)	-	£17 to £18	per ton.
Sodium Sulphite (anhydrous)	-	£27.10	,,
Wood Creosote (unrefined)	-	2/9 per gallon	

Oil Seeds, Oils, and Oil Cakes.—The market for oil seeds was strong towards the end of 1924, but had eased off by the February returns available. The price of Palm kernels (West African) started firm but became quiet in January. Palm kernel oil cake remained normal with a scarcity of stock. Oil and oil cakes have followed the trend of oil seeds. Groundnut, and ground nut cake are perhaps the exceptions, the market remaining steady, although on rather a lower level.

Essential Oils, Spices and Drugs.—The essential oil market calls for better comment. Prices have remained at round the same level ruling three months ago.

Natural Dyestuffs and Extracts.—Prices remain normal. The Chemist and Druggist, February 28, 1925 contains the following note on Annatto seed:

> "The new food preservative proposals issued by the Ministry of Health for discussion prohibit the use of gamboge and a number of coal-tar dyes giving a yellow colour. As this also refers to foods imported into this country (England), it is anticipated that Annatto seed, which is at present used only in small quantities, will find a greater outlet, this being one of the very few yellow dyes upon which a veto is not placed. Forward business has been quiet, and prices quoted are only normal. For fair Madras and Jamaca on the spot, 1924 crop, 1/- to 1/3 per lb. is asked."

In view of the fact that annatto grows freely in this country, this statement is of peculiar interest locally, for should the Ministry of Health proposals be accepted, it is bound to stimulate the annatto market.

Cotton and Fibres.—The forecast of the cotton crop for 1924—1925 from countries which supply an aggregate of about 80% of the world's production shews that the yield for the current season furnishes an increase of 27% as compared with last year's outturn. The American crop will supply the largest total for nine years.

Messrs. Ide and Christie report (January 15) that the Manila Hemp Market has ruled dull and uninteresting, with very little business passing. The most noticeable feature has been the continued active demand from the United States for the fine grades of hemp for which a considerable advance is recorded.

This Market Price List is based on the quotations contained in the following periodicals and lists:

Lewis and Peat Ltd. Monthly Prices Current (Baltic Dept.) (9-12-24, 12-2-25).

Lewis and Peat Ltd. Monthly Prices Current (Baltic Dept.) (10-12-24, 4-2-25).

Lewis and Peat Ltd. West Indian, Central America and Bazilian Monthly market report 10-12-25, 26-1-25.

British Trade Journal, January, February, 1925.

Fertilizers and Feeding Stuffs Journal, December, 1924, January, February, 1925 issues.

Chemist and Druggist, January and February, 1925 issues.

Chemistry and Industry, January and February, 1925 issues.

Chemical Age, January and February, 1925 issues.

Received for publication 2nd April, 1925.

Publications of the Department of Agriculture.

The following publications, except those out of print, may be obtained on application to the Office of the Secretary for Agriculture; and the Malay States Information Agency, 88, Cannon Street, E.C. London.

A remittance to cover the cost should accompany applications; otherwise the Journals will be sent by post, Cash on Delivery, where that system is in force.

1. The Agricultural Bulletin F.M.S.

Vols. I—IV (1913-16) VIII & IX (1920-21) price $5.00 per volume.
Vol. V (1917) Nos. 1, 2, 3, 5 & 6 „ 2.50 per set.
„ VI (1918) „ 1, 7, 8 & 12 „ 2.00 „
„ VII (1919) „ 2—6 „ 4.50 „

2. The Malayan Agricultural Journal (continuing the Agricultural Bulletin). Published monthly.

Vol. X (1922) Price $5.00 per volume.
„ XI (1923) Price $5.00 per volume or 50 cents per single number.

Back numbers of Vols. I—X will not be sold singly.

3. The Handbook of Malayan Agriculture, price $1.00.

Current numbers of the Malayan Agricultural Journal and the Handbook may be purchased at the Railway Bookstalls and Branches of Messrs. The Federal Rubber Stamp Co.

4. *Special Bulletins.*

1. Notes on *Termes Gestroi* and other species of Termites found on Rubber Estates in the Federated Malay States, by H. C. Pratt, Government Entomologist, 1909, 20 cts.
2. Root Diseases of *Hevea Brasiliensis*, by W. J. Gallagher. C
3. Observations on *Termes Gestroi* as affecting the Para Rubber Tree and methods to be employed against its Ravages, by H. C. Pratt, Government Entomologist, 1910, reprint 1916, 20 cts. (Out of Print.)
4. A Lepidopterous Pest of Coconuts, *Brachartona catoxantha, Hamps*, by H. C. Pratt, 1909. C
5. The Extermination of Rats in Rice Fields, by W. J. Gallagher, 1909. C
6. Preliminary note on a Branch and Stem Disease of *Hevea Brasilienisis*, by W. J. Gallagher, 1909. C
7. Coffea Robusta, by W. J. Gallagher, Government Mycologist, 1910, 20 cts.
8. The Cultivation and Care of the Para Rubber Tree (in Malay) 1910. C
9. Die-Back Fungus of Para Rubber and of Cacao, by K. Bancroft, 1911. C
10. A Lecture on the Para Rubber Tree, by W. J. Gallagher, 1910. C
11. Coconut Cultivation, by L. C. Brown, 1911. C
12. Padi Cultivation in Krian, by H. C. Pratt, 1911. C
13. A Root Disease of Para Rubber, *Fomes Semitostus*, by K. Bancroft, Assistant Mycologist 1912, 20 cts.

C = Cancelled